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(54) **Device and method for molding motor coils**

Verfahren und Vorrichtung zum Giessformen von Motorwicklungen

Procédé et dispositif de moulage d'enroulements de moteurs

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Description

TECHNICAL FIELD

[0001] The present invention relates to a device and a method for molding coils placed around core teeth of a rotor core of an electric motor with resin material.

BACKGROUND OF THE INVENTION

[0002] Conventionally, it is known that when the coil wire for motor coils is subjected to a tension as it is passed through core slots of a rotor core, the edges of the core teeth could damage the insulating film of the coil wire. Therefore, it has been customary to design a coil forming machine for forming motor coils around core teeth in such a manner as to avoid applying tension to the coil wire. Once the coils are placed around the core teeth, the rotor core is covered by insulating material such as thermosetting resin.

[0003] In such a motor production process, typically, the rotor core is preheated after the coils are placed in the core slots, and the resin material is then coated over the rotor core. The resin coating is adjusted, and is cured. After the resin coating has fully cured, the outer profile of the rotor is cut into a prescribed shape by machining. Although the resin coating process can be carried out by using an automated machine, the process of adjusting the resin coating is required to be carried out manually. Therefore, a significant time period (for instance about 2 hours) must elapse from the start of the pre-heating process to the completion of the curing process. Therefore, the coil wire which has been received in the core slots may spring back out of the core slot during this time period, and a projecting part of the coil wire could be cut by the machine tool during the process of shaping the motor rotor.

[0004] This can be avoided by using wedges to prevent the spring back of the coil wire as illustrated in Figure 5. After the coils 8 are wound around the core 4 of the rotor 3, and before the resin coating is formed, a wedge 11 is inserted into each core slot 4a from an axial end of the rotor core 4 in such a manner as to be engaged by a laterally expanded part of each core tooth 4b, and prevent the wire of the coils 8 from expanding radially out of the core slot 4a. However, when the rotor 3 has a large number of core slots 4a , a corresponding number of wedges 11 have to be inserted in the core slots 4a, and this leads to an increase in the material cost and a complication of the production process.

[0005] Also, according to the conventional motor rotor, the shape of the coil wire extending from the axial end of one core slot into another or the shape of the coil and is relatively indeterminate, and it has been necessary to leave a significant amount of resin coating deposited in this part because of the fear of cutting into the coil wire when cutting the resin coating away from this part. The excessive deposition of resin coating is not desirable as it increases the moment of inertia of the motor rotor, and therefore reduces the performance of the motor.

[0006] United States patent No. 5,634,258 issued June 3, 1997 discloses a method for moulding motor coils in resin material which uses the flow of the resin material to control the spring back of the coil wire. The contents of this patent are hereby incorporated in this application by reference. EP 0793 331 A1, falling under Article 54(3) EPC, discloses a motor coil moulding device for moulding coils wound around a motor rotor with resin material in a die assembly. The die assembly includes upper and lower die halves which are separable and adapted to be closed so as to define a cavity for axially receiving a motor rotor. The die halves can be opened to allow placing and removing of the motor rotor in and out of the die cavity. The motor rotor includes a shaft, a rotor core carried by the shaft and is provided with core slots and coils received within the slots. The cavity includes a main part for receiving the rotor core coaxially therein so as to define a small annular gap between the rotor core and the opposing die surface; a pair of support portions for supporting two shaft ends of the motor rotor; and an intermediate part defined between the main part and at least one of the said support portions. The intermediate part includes a small diameter portion defining a substantially smaller inner diameter than said main part so as to radially compress looped coil ends of the coils. The upper and lower die halves are arranged to be given in a plane orthangonal to the axial line of the motor rotor.

BRIEF SUMMARY OF INVENTION

[0007] In view of such problems of the prior art, a primary object of the present invention is to provide a method and a device for moulding coils placed around a motor core with resin material which can reduce both the material cost and the production cost.

[0008] A second object of the present invention is to provide a method and a device for moulding coils placed around a motor core with resin material which can improve the performance of the motor.

[0009] According to the present invention, these and other objects can be accomplished by providing a motor coil moulding device for moulding coils wound around a motor rotor with resin material in a die assembly, the die assembly including upper and lower die halves which are separable along an axial line of the motor rotor, the upper and lower die halves being adapted to be closed so as to define a cavity for receiving a motor rotor coaxially therein, and opened so as to allow placing and removing the motor rotor in and out of said cavity, the motor rotor including a shaft, a rotor core carried by the shaft and provided with core slots, and coils received in the slots, said cavity including a main part for receiving the rotor core coaxially therein so as to define a small annular gap between the rotor core and the opposing

die surface; a pair of support portions for supporting two shaft ends of the motor rotor; and an intermediate part defined between the main part and a least one of said support portions; said intermediate part including a small diameter portion defining a substantially smaller inner diameter than said main part so as to radially compress corresponding looped coil ends of the coils.

[0010] In a further aspect the present invention a motor coil moulding method for moulding coils wound around a motor rotor with resin material in a die assembly, the die assembly including upper and lower die halves which are separable along an axial line of the motor rotor, the upper and lower halves being adapted to define a die cavity therein, said die cavity including a main part for receiving a rotor core coaxially therein so as to define a small annular gap between the rotor core and the opposing die surface, support portions for supporting two shaft end of the motor rotor in a sealing relationship; and means for constraining a coil end at each axial end portion of the rotor core received in the die cavity, comprising the steps of placing a motor rotor in said die cavity; radially constraining a coil end at an axial end of the rotor core with said coil end constraining means; injecting resin material from a radially peripheral part of said die assembly so as to force coil wire received in core slots radially inward by a flow of said resin material; and curing said resin material deposited around the motor rotor. Typically the method further comprises the step of removing the resin material from an outer circumferential surface of the motor rotor by machining.

[0011] Thus, because the coil end of the motor rotor can be appropriately covered by the smaller diameter portion during the moulding process, the deposition of the resin material over the coil end can be minimized so that the costs for the material and the production can be reduced, and the moment of inertia of the motor rotor can be reduced. Because the coil wire at the coil end is pushed radially inward, the moment of inertia of the rotor owing to the mass of the coil wire is reduced for this reason also. To effectively retain the coil wire in each core slot against the tendency of the coil wire to spring back, the die assembly may include an injection hole for introducing the resin material from a radially peripheral part of the die assembly. The flow of the resin material is thereby directed radially inward, and then axially in either direction in the die cavity so that the flow of the resin material counteracts the tendency of the coil wire to spring back.

[0012] The small diameter portion may either extend from an axial end portion of the cavity to a region adjacent an axial end of the rotor core or be defined by an annular ridge having a relatively small axial width. The small diameter portions may be formed by two halves formed in the upper and lower die halves in either case.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Now the present invention is described in the following with reference to the appended drawings, in which:

figure 1 is a simplified longitudinal sectional view of a die assembly for moulding motor coils with resin material embodying the present invention;

Figure 2 is a flow chart showing the steps of carrying out the molding process according to the present invention;

Figure 3 is a fragmentary cross sectional view of a motor rotor;

Figure 4 is a fragmentary longitudinal sectional view of a second embodiment of the die assembly for molding motor coils with resin material; and

Figure 5 is a view similar to Figure 3 showing a conventional arrangement.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Figure 1 shows a die assembly for injecting resin material into a motor rotor embodying the present invention. This die assembly comprises an upper die half 1 and a lower die half 2 which are supported by a frame not show in the drawing in such a manner as to be opened and closed as desired. When the upper and lower die halves 1 and 2 are closed upon each other, an inner die cavity is defined jointly by inner surfaces 1a and 2a of the upper and lower die halves 1 and 2. The two axial ends of the die assembly comprises support parts 12 for supporting two axial end portions of a core 4 of a motor rotor 3 in a sealing relationship so as to prevent leakage of the resin material from the axial ends. One of the support parts 12 includes a reference surface 5 consisting of an annular shoulder surface for engaging an axial end of a commutator 3a of the rotor 3 so as to position the rotor 3 in the die assembly with respect to the axial direction.

[0015] The upper die half 1 is provided with reduced diameter surfaces 1b and 1c at respective intermediate parts, each defined between a main part of the die cavity and a corresponding one of the support parts 12 so as to oppose a corresponding one of coil end portions of the rotor 3. The lower die half 2 is provided with corresponding reduced diameter surfaces 2b and 2c which cooperate with the reduced diameter surfaces 1b and 1c of the upper die half 1 so as to jointly define reduced diameter portions (1a and 1c; and 2b and 2c) for compressing the corresponding coil ends when the die assembly is closed.

[0016] The reduced diameter surfaces 1b and 1c of the upper die half 1 are respectively provided with injection holes 6a and 6b communicating the interior of the cavity with the outside for introducing fluid resin material under pressure from a resin supply device (not shown in the drawing) into the cavity. The lower die half 1 is provided with knock out pins 7 for ejecting the rotor 3 from the die assembly when it is molded with resin ma-

terial.

[0017] The process of injecting resin material 10 into and around the rotor 3 in this die assembly is described in the following with reference to Figure 2. In step ST1, the rotor having coils 8 wound thereon in the preceding step is placed inside the die assembly, and after being positioned therein by using the reference surface 5, the die assembly is closed. The small diameter portions 1b and 1c, and 2b and 2c jointly defined by the small diameter surfaces constrain or compress the corresponding axial ends of the coils as indicated by the solid-line arrows in Figure 3. Thus, the looped coil ends are compressed into having a smaller radial extent on the one hand, and the coil wire inside the core slots is thereby pulled radially inward on the other hand.

[0018] In step ST2, the resin material is injected into the die assembly from the injection holes 6. The resin material, for instance, may consist of BMC (bulk mold compound) which is heated to the temperature of about 40 °C. The resin material 10 is thus injected from two points located on radially outer peripheral parts at either axial end of the die cavity. The main part defined by the die surfaces 1a and 2a corresponding to the outer circumferential surface of the rotor core 3 is oversized with respect to the outer diameter of the rotor core 3 so as to define an annular gap s (for instance 0.2 to 0.4 mm) between the outer surface of the rotor core 3 and the opposing inner surface of the die assembly. Therefore, when the resin material is injected from the injection holes 7 in step ST2, the resin material initially covers the coil ends on both axial ends of the rotor core, and fills into this annular gap. Then, the flow of the resin material is directed radially inward into each of the core slots. This causes the coil wire to be pushed deeper into the bottom portion of each core slot.

[0019] The time period required for injecting the resin material may be approximately one minute in the case of a rotor core for a small motor having an outer diameter of 70 mm and approximately 30 core slots. The resin material filled into the core is allowed to cure for the time period of about 100 seconds in step ST3. When no resin material is filled into the rotor core, the coils 8 typically spring back in about one hour. However, according to the present invention, because the flow of the resin material forces the coil wire into the core slots, and the resin material is allowed to partially cure while the coil ends are radially inwardly restrained by the small diameter portions of the die assembly, it is possible for the resin material to fully cure before the coils make any appreciable spring back. The rotor core having the coils 8 retained in the core slots by the resin material is then transferred to the next step.

[0020] Conventionally, the resin material was molded over the coil ends so as to define an outer diameter identical to that of the main part of the rotor core, and was thereafter cut away by machining. Therefore, a significant amount of the resin material 10 was required to be removed, and this caused corresponding increases in the material cost and the production cost. On the other hand, according to the arrangement embodying the present invention, the small diameter portions of the die assembly at respective axial ends prevent any excessive deposition of the resin material over the coil ends. Therefore, according to this arrangement, the amount of the resin material required to be removed from the coil ends is minimized, or the process of removing excess resin material from the coil ends may be totally eliminated. As shown in Figure 1, the axial extent L2 that needs to be machined according to the present invention is substantially smaller than that L1 according to the prior art. The imaginary lines A and B indicate the profile of the conventional die cavity. Furthermore, according to the prior art, a resin material layer of a certain depth must be left over the coil ends because of the fear of cutting into the coil wire. According to the present invention, such a fear does not exist, and the thickness of the resin material layer over the coil ends can be substantially reduced so that the moment of inertia of the motor can be reduced, and the performance of the motor can be improved. Also, because the part of the coil wire at each coil end and inside each slot is pushed radially inward by the small diameter portions, the moment of inertia owing to the mass of the coil wire is also reduced.

[0021] Figure 4 shows a second embodiment of the present invention. In this embodiment, a coaxial annular ridge 1d and 2d is defined at each axial end of the die assembly. The annular ridge 1d and 2d is defined by two halves 1d and 2d formed in the upper and lower die halves 1 and 2 of the die assembly. Thus, each coil end is constrained or compressed along a narrow circular region instead of substantially over the entire coil end. Depending on the application, the second embodiment is more preferable because excessive compression of the coil ends may be avoided.

[0022] Thus, according to the above described embodiments, because the unnecessary deposition of the resin material over the coil ends is minimized, the material cost can be reduced. Also, the elimination or the reduction of the need to eliminate excess resin material from the coil ends simplifies the production process, and reduces the production cost. Additionally, the reduction in the mass of the resin material over the coil ends, as well as the constraining of the coil wire into a relatively radially inner parts reduces the moment of inertia of the motor rotor, and can thereby improve the performance of the motor.

[0023] Although the present invention has been described in terms of preferred embodiments thereof, it is obvious to a person skilled in the art that various alterations and modifications are possible without departing from the scope of the present invention which is set forth in the appended claims.

Claims

1. A motor coil moulding device for moulding coils wound around a motor rotor (3) with resin material in a die assembly, the die assembly including upper and lower die halves (1, 2) which are separable along an axial line of the motor rotor, the upper and lower die halves being adapted to be closed so as to define a cavity for receiving a motor rotor coaxially therein, and opened so as to allow placing and removing the motor rotor in and out of said cavity, the motor rotor including a shaft, a rotor core carried by the shaft and provided with core slots, and coils (8) received in the slots, said cavity including:

   a main part for receiving the rotor core coaxially therein so as to define a small annular gap between the rotor core and the opposing die surface;

   a pair of support portions (12) for supporting two shaft ends of the motor rotor; and

   an intermediate part defined between the main part and a least one of said support portions;

   said intermediate part including a small diameter portion (1b, 1c, 2b, 2c) defining a substantially smaller inner diameter than said main part so as to radially compress corresponding looped coil ends of the coils.

2. A motor coil moulding device according to claim 1, wherein said die assembly further includes an injection hole (6a, 6b) for introducing the resin material from a radially peripheral part of said die assembly.

3. A motor coil moulding device according to claim 1, wherein said small diameter portion extends from an axial end portion of said cavity to a region adjacent an axial end of the rotor core, and is formed by two halves formed in said upper and lower die halves.

4. A motor coil moulding device according to claim 1, wherein said small diameter portion is defined by an annular ridge having a relatively small axial width, and formed by two halves formed in said upper and lower die halves.

5. A motor coil moulding device according to claim 1, wherein said support portions are each adapted to sealingly support a corresponding one of said shaft ends.

6. A motor coil moulding method for moulding coils wound around a motor rotor (3) with resin material in a die assembly, the die assembly including upper and lower die halves (1, 2) which are separable along an axial line of the motor rotor, the upper and lower halves being adapted to define a die cavity therein, said die cavity including a main part for receiving a rotor core coaxially therein so as to define a small annular gap between the rotor core and the opposing die surface, support portions (12) for supporting two shaft end of the motor rotor in a sealing relationship; and means (1b, 1c, 2b, 2c) for constraining a coil end at each axial and portion of the rotor core received in the die cavity, comprising the steps of

   placing a motor rotor in said die cavity;
   radially constraining a coil end at an axial end of the rotor core with said coil end constraining means;
   injecting resin material from a radially peripheral part of said die assembly so as to force coil wire received in core slots radially inward by a flow of said resin material; and
   curing said resin material deposited around the motor rotor.

7. A motor coil moulding method according to claim 6, further comprising the step of removing the resin material from an outer circumferential surface of said motor rotor by machining.

Patentansprüche

1. Motorwicklungseingießvorrichtung zum Eingießen von Wicklungen, die um einen Motorrotor (3) geschlungen sind, mit einem Kunstharzmaterial in einer Gießform, die eine obere Gießformhälfte (1) und eine untere Gießformhälfte (2) umfasst, die sich entlang einer Axiallinie des Motorrotors (3) trennen lassen und in geschlossenem Zustand einen Hohlraum bilden, der einen Motorrotor axial aufnimmt, und in geöffnetem Zustand ermöglichen, den Motorrotor in den Hohlraum einzulegen und diesem zu entnehmen, wobei der Motorrotor eine Welle, einen auf dieser Welle sitzenden und mit Kernnuten versehenen Rotorkern und Wicklungen (8), die von diesen Nuten aufgenommen werden, umfasst, und der Hohlraum

   - einen Hauptabschnitt, der den Rotorkern dergestalt koaxial aufnimmt, dass zwischen dem Rotorkern und der Innenseite der Gießform ein kleiner ringförmiger Spalt gebildet wird,
   - zwei Halteabschnitte (12), die die beiden Enden der Welle des Motorrotors halten, sowie
   - einen Zwischenabschnitt, der zwischen dem Hauptabschnitt und mindestens einem der Halteabschnitte (12) gebildet ist, umfasst,

wobei dieser Zwischenabschnitt einen Abschnitt (1b, 1c, 2b, 2c) umfasst, dessen Innendurchmesser bedeutend kleiner ist als derjenige des Hauptabschnitts, so dass die Wicklungen an den Schleifenenden radial zusammengedrückt werden.

2. Motorwicklungseingießvorrichtung nach Anspruch 1, bei der die Gießform weiterhin ein Einspritzloch (6a, 6b) zum radialen Einfüllen des Kunstharzmaterials von der Umfangsseite der Gießform umfasst.

3. Motorwicklungseingießvorrichtung nach Anspruch 1, bei der der Abschnitt (1b, 1c, 2b, 2c) mit kleinerem Durchmesser sich von einem axialen Endabschnitt des Hohlraums bis zu einem Bereich in der Nähe des axialen Endes des Rotorkerns erstreckt und aus zwei Hälften, die in der oberen und unteren Gießformhälfte gebildet sind, gebildet ist.

4. Motorwicklungseingießvorrichtung nach Anspruch 1, bei der der Abschnitt (1b, lc, 2b, 2c) mit kleinerem Durchmesser durch einen ringförmigen Grat mit relativ kleiner axialer Breite und aus zwei Hälften, die in der oberen und unteren Gießformhälfte gebildet sind, gebildet ist.

5. Motorwicklungseingießvorrichtung nach Anspruch 1, bei der die Halteabschnitte (12) so ausgebildet sind, dass sie jeweils ein Ende der Welle halten und gleichzeitig abdichten.

6. Motorwicklungseingießverfahren zum Eingießen von Wicklungen, die um einen Motorrotor (3) geschlungen sind, mit einem Kunstharzmaterial in einer Gießform, die eine obere Gießformhälfte (1) und eine untere Gießformhälfte (2) umfasst, die sich entlang einer Axiallinie des Motorrotors (3) trennen lassen und so ausgebildet sind, dass sie zusammen einen Hohlraum bilden, der einen Hauptabschnitt, der einen Rotorkern dergestalt koaxial aufnimmt, dass zwischen dem Rotorkern und der Innenseite der Gießform ein kleiner ringförmiger Spalt gebildet wird, Halteabschnitte (12), die die beiden Enden der Welle des Motorrotors halten und gleichzeitig abdichten, sowie Mittel (1b, 1c, 2b, 2c) zum Zusammenpressen eines Wicklungsendes am axialen Endabschnitt des vom Hohlraum der Gießform aufgenommenen Rotorkerns umfasst, mit den Schritten

- Einlegen eines Motorrotors in den Hohlraum,
- radiales Zusammenpressen eines Wicklungsendes am axialen Endabschnitt des Rotorkerns mit den genannten Mitteln (1b, 1c, 2b, 2c),
- radiales Einspritzen von Kunstharzmaterial in die Gießform, so dass der von Kernnuten aufgenommene Wicklungsdraht durch das strömende Kunstharzmaterial radial nach innen gedrückt wird, sowie
- Aushärten des auf dem Motorrotor aufgebrachten Kunstharzmaterials.

7. Motorwicklungseingießverfahren nach Anspruch 6, das weiterhin den Schritt des Entfernen des Kunstharzmaterials von einer äußeren Umfangsfläche des Motorrotors durch spanabhebende Bearbeitung umfasst.

Revendications

1. Dispositif de moulage de bobine de moteur pour mouler des bobines enroulées autour d'un rotor de moteur (3) avec un matériau de résine dans un assemblage de matrice, l'assemblage de matrice comportant des moitiés de matrice supérieure et inférieure (1, 2) pouvant être séparées sur une ligne axiale du rotor du moteur, les moitiés de matrice supérieure et inférieure étant adaptées pour être fermées de façon à définir une cavité pour recevoir de façon coaxiale dans celle-ci un rotor de moteur et ouverte de façon à permettre le placement et le retrait du rotor de moteur dans et hors de ladite cavité, le rotor de moteur comportant un arbre, un noyau de rotor porté par l'arbre et muni de fentes de noyau et des bobines (8) reçues dans les fentes, ladite cavité comportant :

   une partie principale pour recevoir de façon coaxiale dans celle-ci le noyau du rotor de façon à définir un petit espace annulaire entre le noyau du rotor et la surface de matrice opposée ;
   une paire de parties support (12) pour supporter deux extrémités de l'arbre du rotor du moteur ; et
   une partie intermédiaire définie entre la partie principale et au moins l'une desdites parties support ;
   ladite partie intermédiaire comportant une partie de petit diamètre (1b, 1c, 2b, 2c) définissant un diamètre interne sensiblement plus petit que ladite partie principale de façon à comprimer radialement les extrémités de bobines en boucle correspondantes des bobines.

2. Dispositif de moulage de bobine de moteur selon la revendication 1, dans lequel ledit assemblage de matrice comporte en outre un trou d'injection (60, 6b) pour introduire le matériau de résine depuis une partie radialement périphérique dudit assemblage de matrice.

3. Dispositif de moulage de bobine de moteur selon la revendication 1, dans lequel ladite partie de petit diamètre se prolonge depuis une partie d'extrémité

axiale de ladite cavité jusqu'à une région adjacente à une extrémité axiale du noyau du rotor et est formée par deux moitiés formées dans lesdites moitiés de matrice supérieure et inférieure.

4. Dispositif de moulage de bobine de moteur selon la revendication 1, dans lequel ladite partie de petit diamètre est définie par une arête annulaire ayant une largeur axiale relativement petite et formée par deux moitiés formées dans lesdites moitiés de matrice supérieure et inférieure.

5. Dispositif de moulage de bobine de moteur selon la revendication 1, dans lequel lesdites parties support sont adaptées chacune pour supporter de manière étanche une extrémité correspondante des dites extrémités d'arbre.

6. Procédé de moulage de bobine de moteur pour mouler des bobines enroulées autour d'un rotor de moteur (3) avec un matériau de résine dans un assemblage de matrice, l'assemblage de matrice comportant des moitiés de matrice supérieure et inférieure (1, 2) pouvant être séparées sur une ligne axiale du rotor du moteur, les moitiés de matrice supérieure et inférieure étant adaptées pour définir une cavité de matrice à l'intérieur, ladite cavité de matrice comportant une partie principale pour recevoir de façon coaxiale dans celle-ci un rotor de moteur de façon à définir un petit espace annulaire entre le noyau du rotor et la surface de matrice opposée des parties support (12) pour supporter deux extrémités de l'arbre du rotor du moteur en relation étanche ; et des moyens (1b, 1c, 2b) pour contraindre une extrémité de bobine à chaque partie d'extrémité axiale du noyau de rotor reçue dans la cavité de matrice, comprenant les étapes consistant à

placer un rotor de moteur dans ladite cavité de matrice ;
contraindre radialement une extrémité de bobine à une extrémité axiale du noyau de rotor avec lesdits moyens de contraintes d'extrémité de bobine ;
injecter un matériau de résine depuis une partie radialement périphérique dudit assemblage de matrice de façon à forcer le fil de bobine reçu dans des fentes de noyau radialement vers l'intérieur par un flux dudit matériau de résine ; et
faire durcir ledit matériau de résine déposé autour du rotor de moteur.

7. Procédé de moulage de bobine de moteur selon la revendication 6, comprenant en outre l'étape consistant à enlever le matériau de résine d'une surface circonférentielle externe dudit rotor de moteur par usinage.

Fig. 1

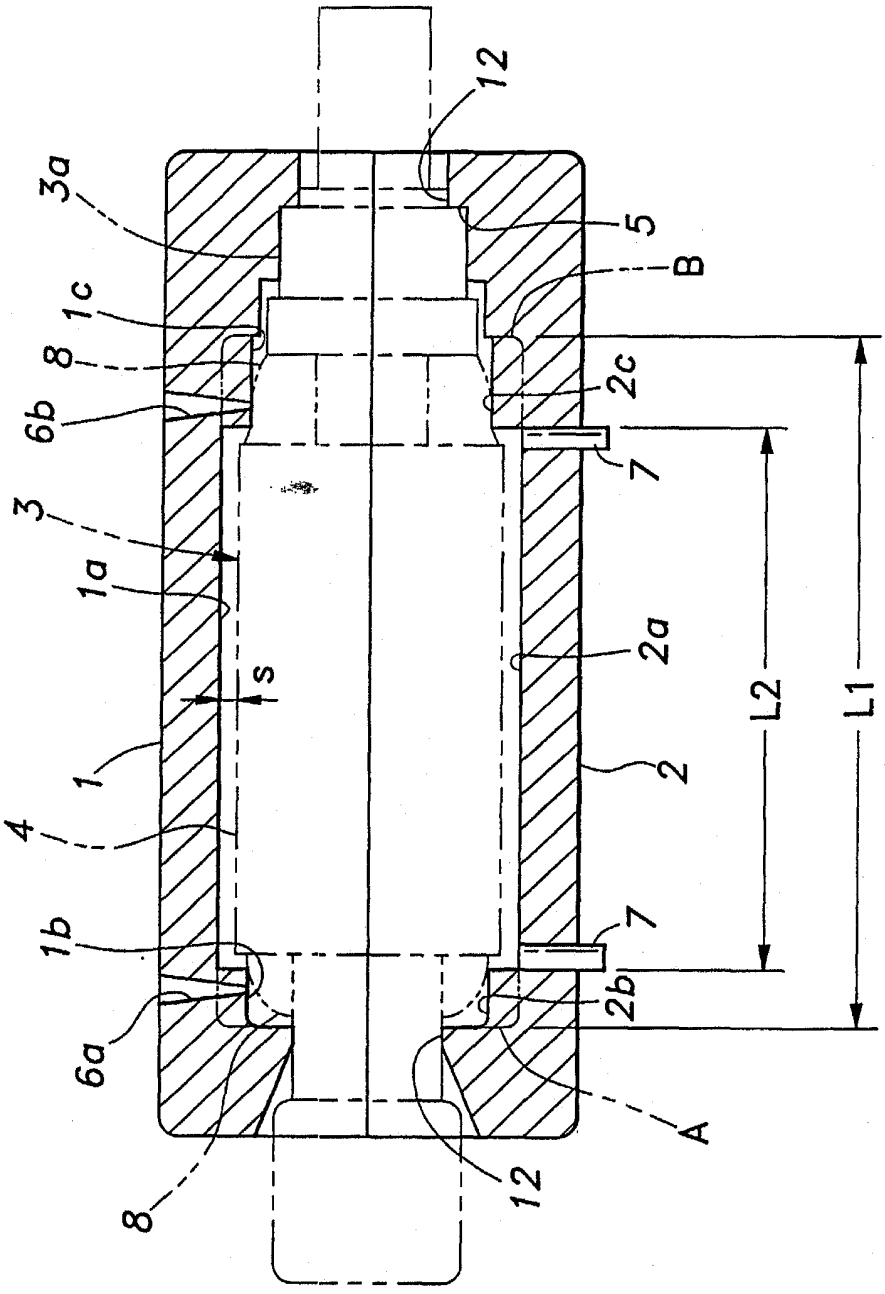

Fig. 2

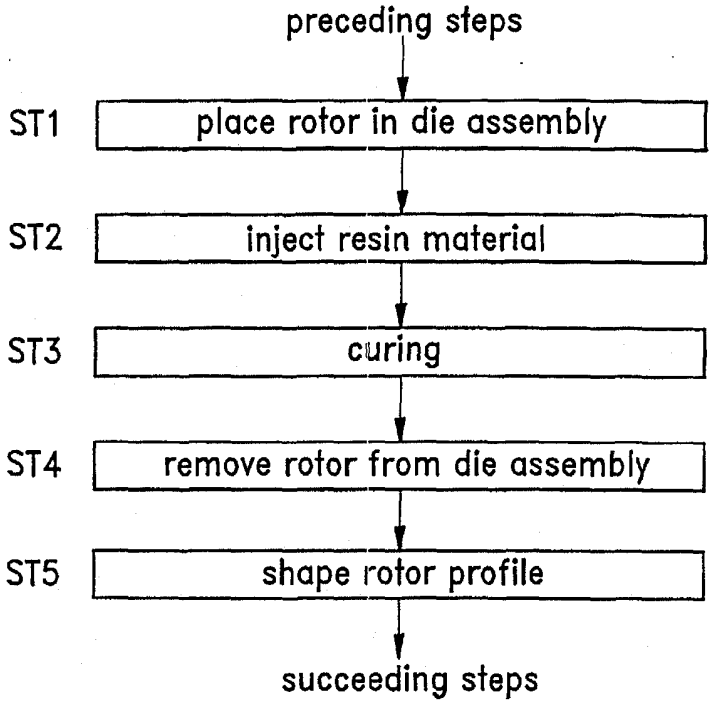
preceding steps
ST1
place rotor in die assembly
ST2
inject resin material
ST3
curing
ST4
remove rotor from die assembly
ST5
shape rotor profile
succeeding steps

Fig. 3

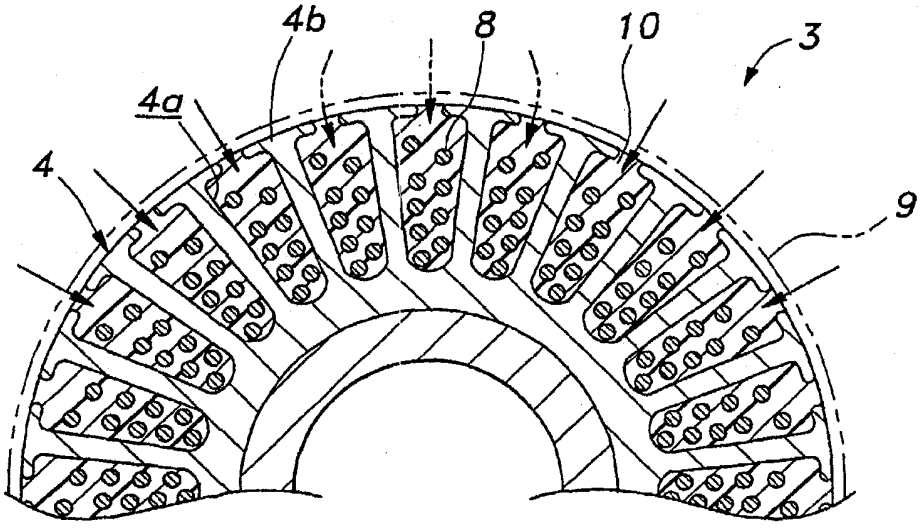
4b
8
10
3
4a
4
9

Fig. 4

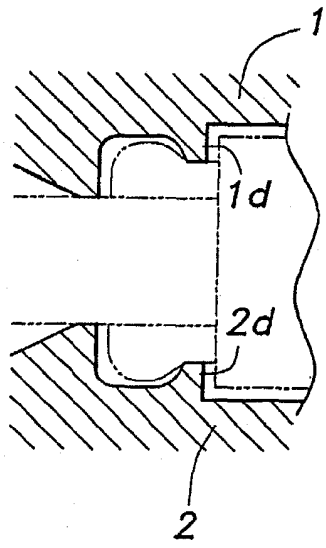

Fig. 5